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This research is one component of a team effort with the goal of using existing science to represent the uncertainty in the tactical and environmental picture to improve acoustic tracking and localization of submarines. The project objective was to develop an end-to-end system that incorporates the uncertainties in the sound speed field, the bottom sediment properties, and the internal wave field, to determine the ultimate uncertainty in the estimation of undersea targets as would be detected on board a submarine. This part of the project focused on characterizing the perturbations caused by the internal wave field and its effect on acoustic propagation.

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Capturing Uncertainty in the Common Tactical-Environmental Picture

Abstract:

This research is one component of a team effort with the goal of using existing science to represent the uncertainty in the tactical and environmental picture to improve acoustic tracking and localization of submarines. The project objective was to develop an end-to-end system that incorporates the uncertainties in the sound speed field, the bottom sediment properties, and the internal wave field, to determine the ultimate uncertainty in the estimation of undersea targets as would be detected on board a submarine. This part of the project focused on characterizing the perturbations caused by the internal wave field and its effect on acoustic propagation.

Final Report:

The overall goal of the project was to track the cumulative uncertainty in our knowledge of the environment and determine how this uncertainty would affect the estimation of undersea targets as detected on board a submarine. An unusual and exceptional aspect of this project was the gathering of expertise from diverse disciplines to work on an end-to-end system. Our team consisted of acousticians with experience in the applied problem of target detection as well as acousticians with knowledge of sound propagation through a fluctuating ocean. Other members of the team were oceanographers who were able to quantify the nature of the variability of the ocean and ocean bottom in time and space. My contribution to the effort focused on the perturbation of the sound speed field due to the presence of internal waves. Part of the challenge for this diverse group was to learn to speak the same language and to understand the impact of their part of the project to the overall uncertainty of the entire system.

The investigation began by considering the continental shelf on the Mid-Atlantic bight as a test site for our study. The statistics of the internal wave field in time and space were characterized using a Garrett-Munk spectral formulation modified for shallow water. The primary input to this formulation was the buoyancy frequency profile. The ocean data were provided by a team member using the Navy's MODAS data base of vertical profiles. The uncertainty in the MODAS data and its effect on the internal wave estimate was explored. The study area was then moved to the East China Sea. Again MODAS data was used. The currents and water mass characteristics are quite complicated in this region. A cluster-type analysis was used to help determine the most likely temperature profile that would exist in this region at a specific time of year. Using this information, estimates of the most likely buoyancy frequency profile were made. Using the spectral formulation of the internal wave field, statistical realizations of the ocean variability of the sound speed in time and space were made. These realizations were then input into an acoustic model to determine the resulting effect on acoustic propagation.

Although work remains to account for full distributions of environmental variability, this project represents the initial step in building an end-to-end system to represent to fleet operators the effects of environmental uncertainty in terms of its effects on a tracker. This sets the stage for further basic and applied research.

The overall project is described in a Final Team Summary submitted to ONR by the team leader Robert Miyamoto (APL/University of Washington). A publication of the acoustics is published in the US Navy Journal of Underwater Acoustics. The effect of the internal wave variability on the acoustic propagation is given in the technical report: DRI Internal Wave Simulations by Stephen A. Reynolds and Murray D. Levine, Technical Memorandum, APL-UW TM 5-04, Applied Physics Laboratory University of Washington, 2005.